Dear Ela,

Thanks for the comments! As Juan has mentioned to you, the current plan is to start with the Nature paper and try to publish PRL as well. Please, see a separate comment about the emphasis on the better consistency between the new indirect limits on the Higgs mass and directly excluded range used in this paper. The three sentences you have commented on have been changed to soften the point.

Greg

From: Emanuela Barberis [barberis@fnal.gov]
Sent: Friday, January 09, 2004 12:34 AM
Subject: comments on Top Mass paper for Nature

Dear all, no comments at this point to the analysis, which deserves prompt publication. I have no particular objection towards publication in Nature vs. PRL, but I am very troubled by the (several) statements on the shift of the most probable value of the Higgs mass which were added w.r.t the original PRL draft (PRL draft which I thought was very good).

We went to a great deal of explaining (in a rigourous statistical way) why the new result is not incompatible with previous D0 result, but we now end up putting emphasis on a shift in a most probable value with absolutely no mention of its uncertainty and significance.

I would suggest to:
- drop the last paragraph of the abstract (i.e. "This value corresponds to an increas in the most likely .... a value more consistent with the SM").
- refer to Fig. 2 in page 3. with a statement of the kind: "This result correponds to a shift in the most probable value of the expected Higgs mass to a region of /approx 125 GeV (see Figure 2)" or else quote the appropriate significance
- drop the last paragraph of the caption of Figure 2 (i.e. "The improved top mass eliminates ....and experimental excluded masses").

Best regards
Ela

Dear Sijbrand,

Thanks again for the comments. Please find, embedded, replies to the specific points you've raised in both e-mail messages you sent us.

Best regards,

Greg

From: Sijbrand de Jong [sijbrand@hef.kun.nl]
Sent: Tuesday, December 30, 2003 10:39 AM
Subject: Re: Nature draft for group/collaboration review

Dear All,

I read the new draft of the Nature paper. I think it is much improved (for the purpose of Nature publication) compared to the very first attempt.

I have one major objection:
The paper suggests at several places (page 1 at end of bold section, page 3 below final result, caption of Fig.2) that the newly measured, higher top mass is more consistent with the Standard Model. I have two problems here:
1. A 125 GeV Higgs is NOT consistent with the Standard Model at high energy scales. (A ~180 GeV Higgs would be...)
2. The statistical significance of any discrepancy with direct searches does not allow to make any claims in that area. Within one sigma the "old" Higgs mass estimate from the top mass and EW data was perfectly fine with the excluded region. I really think this should be phrased more carefully, i.e. not suggesting things that are (statistically) not there.

We have summarized the reasons why it is important to make the shift in the Higgs mass the major theme of this paper in a separate statement that preludes replies to the collaboration comments. The sentences you commented on have been changed to soften this point. I hope you will find them more consistent with your vision. Particularly, we agree that the statement about better consistency with the SM is incorrect; this has been replaced with better consistency with direct searches.

Some minor things:

page 1: "... with the Higgs field that supposedly permeates our entire universe..."
What is the goal of adding this qualification to the Higgs field ?
The top field also permeates our entire universe (and so do all other fields...)

Without getting too philosophical here, I'd say that only gauge fields permeate the entire universe. Top is fairly well localized via its wave function, so the goal of this sentence was to unveil the mystery of where the Higgs comes from. Granted, it's probably a cliché and does not really explain much, but that's the best we came up with so far, and the editor didn't have problems with it either.

page 3: the introductory paragraph of the section "Top Mass Extraction"
repeats what has been said before (and even admits that with the

phrase "as indicated above"). Instead, maybe the concept that one compares a set of measured quantities to the theoretical probability that they occur as such can be introduced.

This has been changed in the 12/29 version of the paper and in the new version. Repetitions have been minimized to bare minimum.

page 4: after the formula for P_ttbar, which uses a script M for the matrix element, it refers to |M_ttbar|^2 with an italic M (which is confusing since italic M's are also used for masses in the preceding formula.)

Thanks – this has been fixed.

page 8: Should it be mentioned in the caption of Fig. 1 that also leptonic W decay into mu nu instead of e nu and hadronic W decay into other quark combination are considered in the analysis ?

Good point. The following sentence has been added to the caption:

This particular final state ($e\bar\nu u \bar d$) is one of several possible final states used in the analysis.

page 9: The label "All Data" in Fig. 2 is not quite descriptive. Can it be changed to something like "All Data with previous M_T", and the label for the red dashed line into "All Data with new D0 M_T" ?

page 10:The y-axis label of Fig. 3 runs over the 22.5 axis value.

page 11:The axis labels of Fig. 4 run over the axis values (both x- and y-axis)

All the figures have been cleaned up and reworked.

In general I would add a D0 logo to the figures, this helps people to acknowledge where things are coming from after they copied them.

Wholeheartedly agree. Done.

Kind regards, Sijbrand.

From: Sijbrand de Jong [sijbrand@hef.kun.nl]
Sent: Tuesday, December 30, 2003 5:49 PM
Subject: Re: Nature draft for group/collaboration review

Hello Tom,

Concerning your last point:
On Tue, 30 Dec 2003, Tom Ferbel wrote:
> > In general I would add a D0 logo to the figures, this helps people
> > to acknowledge where things are coming from after they copied them.

> >
> ==> Enough shameless propaganda? Not appropriate?

This is what the LEP experiments did all the time. Could this have been the reason why they got more attention in the 90's than the Tevatron experiments ?
Of course one should not exaggerate, but a non-distracting, not overly large (but also not too small), cute B&W printable D0 logo would be nice.

Done!

Concerning alternatives to the claims that the high top mass puts the SM from troubled back to normal, my suggestions:

At the end of the bold introductory section:
"This value corresponds to an increase of the most likely value of the Higgs mass by more than 30%, from 96 GeV/c^2, which is in the region excluded by direct searches, to \approx 125 GeV/c^2."

The sentence has been changed and now reads:

This value corresponds to an increase of the most likely value of the Higgs mass by more than 30\%, from $\bm{ 96}$ GeV/$\bm{c^2}$, which is in the excluded region, to $\bm{\approx 125}$~GeV/$\bm{c^2}$, a value more consistent with experiment.

The section just before the "Top Mass Extraction" header:
"This result shifts the value of the expected Higgs mass to a region of \approx 125 GeV/c^2 (see Figure 2), just above the region excluded by direct searches at LEP. This expected Higgs mass can be accessed in the current run of the Tevatron and at the future LHC."

BTW: Note that in the original sentence GeV was used as the mass unit instead of GeV/c^2.

The sentence has been changed and now reads:

This result corresponds to the most accurate measurement of the top quark mass in any single experiment and shifts the value of the expected Higgs mass to ≈ 125 GeV/c^2 (see Figure~\ref{fig:blueband}), which is consistent with the experimentally excluded region and still can be accessed in the current run of the Tevatron and at future runs at the Large Hadron Collider.

Last line of the caption of Fig. 2:
"The improved top mass measurement puts the most likely value of the Higgs mass above the experimental excluded masses."

Done.

If you need to spice up the article, another potentially interesting observation is that the top Yukawa coupling, M_T/(sqrt(2)*v), tends to get larger than 1. for M_T>175 GeV and v=246 GeV. What does that mean ? Is it worth making this observation in this paper ?
(Is my formula for the Yukawa coupling right (I am ding this from the top of my head, no books around) ?)

While your formula is almost correct (sqrt(2) should be in the numerator), the measured value of the top Yukawa coupling is still one (1.03 +- 0.03), so I don't see why the change is interesting. Moreover, as the top Yukawa coupling runs, its value is of a particular interest only at a scale where the EWSB is broken (or whatever is the energy scale that is ultimately responsible for the fermion masses). While the running is logarithmic, the Yukawa coupling changes by a few per cent between 100 GeV and 1 TeV, so playing on its value being exactly one would be a bit too far stretch toward numerology.

Kind regards, Sijbrand.

Hi John,

Thanks for the comments and congratulations! Most of your points have been addressed. Please, see embedded comments for detail. Your question has been answered by Gaston already.

Greg

From: John Ellison [john.ellison@ucr.edu]
Sent: Thursday, January 08, 2004 5:16 PM
Subject: comments on top mass article for Nature

Hi all,

This is a great paper, congratulations to the authors. I have one question and some minor style comments:

1) page 1, penultimate line
W should be italic

Done.

2) page 2, line 4
Shouldn't "solution" be changed to "solutions", since we are referring to a set of models?

Done.

3) page 2, second para, line 1
The new method -> The new mass measurement method

Done.

4) page 3, line 5
Reference 14 appears too early, directly after reference 10, so it looks like the order of the references is not correct.

References reordered.

5) page 4, line 5
Why is the last sentence in parenthesis? It seems that we should delete them.

Good point. Moved this lonely sentence as the last clause two sentences above.

6) page 4, para 2, line 3
Is it true that A(x) is independent of M_t? I would naively assume that the acceptance could depend on M_t, since the event kinematics (average p_T's etc.) would change?

It is true; see Gaston's reply for detail.

7) page 4, line 12
etc -> etc.

Done.

8) page 5, para 3, line 2
N should be italic (N-event)

Done.

--John

Dear Martin,

Thanks for the detailed comments and also for your help with Figure 2 of the Nature paper! Please, find replies to your comments below, as well as in the preamble to the collaboration comments, which explains a bit better why the emphasis in this paper has been put on the Higgs mass shift.

Best,

Greg

From: Martin Grunewald [mwg@fnal.gov]
Sent: Friday, January 09, 2004 12:51 PM
Subject: Nature draft: Improved Precision on the Mass of the Top Quark

Dear colleagues;

Here are a few comments on the Nature Draft version of the Mtop measurement. In summary, the wording on the conflict of 96 with
114 is too strong (even if just to raise interest, it is still much too strong!), and the extraction section is too technical for Nature.

The wording has been changed to make the point softer. Please, see the new text for detail.

Abstract:

"A pressing problem" is way too strong a wording. That the central value is below the limit is NO problem as the central value has an uncertainty assigned to it: the 68%CL uncertainty range extends well beyond the limit of 114 GeV.
Please drop the part "A pressing problem for the SM is that", and start the sentence with "Based on ..."

Changed to “A potential problem…”

At the end of the sentence, [2] is cited where [2] is the LEP-EWWG etc.
In fact you need to add the reference to the direct search limit (the
114 GeV) from the LEP Higgs Working Group: preprint hep-ex/0306033, published as Phys. Lett. B565 (2003) 61.

Thanks, the reference has been added.

My averaging program yields 179.0+-5.1 GeV instead of +-5.2 GeV, since stat and syst errors are only after rounded equal to 3.5 and 3.8 GeV (those do round to 5.2, but why accumulating rounding
effects?)

Thanks, this has been corrected.

Last sentence of abstract: please re-phrase to:
"about 30\%, from 96+60-38 GeV which is mostly in the excluded reagion, to $123 +76 -50 GeV$"
(that number is as `precise' as the

96 GeV written earlier without \approx).

The most likely value of the Higgs mass does not have an error associated with it. It's merely the position of the minimum of the curve. Figure 2 contains all necessary information about one sigma or two sigma uncertainties – we are not hiding anything here. No change.

Page 2:

middle: intergated luminosity of 125/pb (Not 125 events/pb)

We argued a lot about it, and decided that events/pb is more appropriate for Nature audience. Since an event is a dimensionless parameter, both notations are correct. No change.

Last line: "In the previous analysis [6]" and following, reads funny:
Who cares about a systematic in the previous analysis? Isn't the old JES error applied to THIS NEW analysis? It seems we talk about the old analysis - better simply use: "As in the previous analysis [6]..."
(actually, this comment also applies to the PRL version).

Good point – taken.

Page 3:

Change $\approx 125~\GeV$ to $123 GeV$ (see above).

Done, and also in the bold section.

Page 3 ff: Section on Top Mass Extraction
For a Nature article I consider this part much too technical: The non-particle-physicist scientist reader, even if a physicist, does not know about `partonic differential cross section', `leading-order matrix element', `CTEQ4M parton distribution functions' and `all possible neutrino solutions', HERWIG MC (should be spelled out as "Monte Carlo simulation", and HERWIG should get a reference), etc.

Didn't the Nature editor and/or referee complain? Or is this the section for the particle physicists, and the the non-expert is supposed to stop reading on page 3?

The suggestion from the edito was to move this in a separate section, as we did. He did not complain about the complexity of this section, but I agree that if the paper is too long, this section will be the first to get cut.

Page 4:

Middle: and the known _detector_ resolution (add "detector")

Done.

Following line: replace "sharp" by "well measured"

Done.

Page 5:

"...this correction must be applied..." =>
"...this correction IS applied..." (at least I hope it is!)

Good point, done.

Page 5 and thus the article does end somewhat abruptly, and
only with central value and stat. error of the l+j result.

I suggest a final sentence: "Combined with our earlier result [3],
our new combined Run-I value is 179.0+-5.1 GeV"

The following sentence added:

Combined with our earlier result~\cite{dilep11}, and accounting for systematic uncertainty, the new D\O\ combined Run I measurement yields the top mass of 179.0 ± 5.1~GeV/c^2.

Page 7 Ref[14]: this reference is close to useless (except
for giving credit, of course): a reader outside URochester
cannot get hold of the theses. If the theses are somewhere
on the web please give at least the web site - or the D0
web site collecting D0 theses (this comment also holds
for the PRL version).

Fermilab preprint number is added to the reference. This reference is in SPIRES and available for download from there.

Page 9 caption figure 2: "eliminates the previous conflict"
`conflict' is again too strong a wording. Simply state: "In
contrast to before, the most likely value of the Higgs mass
now lies [comfortably] above the limit from the direct search."

Wording has been changed to soften the statement.

Best regards

Martin

--

Martin W. Gruenewald e-mail: mwg@fnal.gov
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Dear Sharon,

Thank you very much for nice words and attentive reading. See a brief rejoinder, below.

Best,

Greg

From: Sharon Hagopian 850-644-4777/630-840-8384 [hagopian@hep.fsu.edu]
Sent: Tuesday, January 06, 2004 5:00 PM
Subject: comments on Run I Top Mass paper for NATURE

Dear Authors and Helpers,

The Run I Top Mass article for Nature magazine is very clear and well-written. I only have one question and a couple of comments about it.

1. Will the figures be published in color? If not, the figure captions and perhaps the figure styles should be changed.

Yes, the figures are going to be published in color. However, we made an effort to have them clearly printable in B&W in the new version of the paper. There are substantial improvements to the figure quality, thanks to Ann Heinson's help.

2. The value of the top mass used for the MC events for the discriminant shown in Fig. 3 should be given. That makes the dependence on mass more clear.

It is 175 GeV/c^2. A note is added to the caption.

3. Ref. 14 should have the Fermilab preprint numbers added, since these theses are available through both SPIRES and Fermilab. Perhaps the information could be placed in parenthes (FERMILAB-THESIS-2001-07, unpublished) for Estrada and (FERMILAB-THESIS-2003-22, unpublished) for Canelli.

Done.

Glad you wrote this paper!
Sharon Hagopian

From: Ann Heinson [heinson@phyd0.ucr.edu]
Sent: Thursday, January 08, 2004 6:37 PM
Subject: comments on the top mass Nature paper

Dear Colleagues,

I really like this new paper and the way it points out the significance and implications of the new measurement. We should include such information in our papers more often.

Here are my comments on the new paper (in the order they appear in the paper, not order of importance).

Best regards,
Ann

+---+
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+---+

Dear Ann,

Thanks for the nice words and detailed comments as well as for your help with figure editing! Most of your suggestions have been incorporated in the text. Please see below for specific comments.

Greg

Abstract

(line 5) of the top quark (Mt) and of the W boson (MW) -> of the top quark (Mt) and W boson (MW)

Done.

(line 6) standard model -> Standard Model (to match line 1 and elsewhere)

Done.

Para 1

(line 7) top-quark -> top quark (nothing comes after it, like "decay" to necessitate the hyphen)

Glad you caught it – done.

(line 7) W boson -> W boson

Done.

(line 8) I am not sure what is meant by "<" 0.1%. OK, so you have abbreviated "better than", but it is mathematically vague - how much better than?. Why not put "to a precision of 0.03%" (or whatever it is right now) and avoid this ambiguity.

It's ~0.05% now (80.423 +- 0.039 GeV) . Changed <0.1% to 0.05%.

(line 12) solution -> solutions (the supersymmetric models should be the solutions, and not the class as one solution)

OK, although one could treat the whole class as a theoretically preferred solution as well.

Para 2

(line 1) Move reference "[6]" to the end of the sentence as it is referring to the previous DZero measurement and not to DZero or the Tevatron collider.

OK.

(line 2) Define "ppbar", since it is used later: proton-antiproton
($p{\bar{p}}$) interactions.

OK.

(line 3) What is an anti-gold nucleus? I can guess, but probably it would be less confusing to write the analogy in some other manner. This notation is very HEP-centric, and most readers will not be HEP people.

Agreed. Changed to:

The total energy of 1.8 TeV released in a head-on collision of a 900 GeV p and 900 GeV $\bar p$ is almost as large as the rest energy of ten gold nuclei.

(line 5) one of the produced W bosons -> one of the W bosons (there are no others but "produced" ones)

Done.

(line 11) After the sentence ending "ttbar pairs.)" I would strongly suggest adding the following sentence: "The previous result in this decay channel is x +- y (stat) +- z (syst) GeV/c^2." The reason is that the title of the paper is "Improved Precision on the Mass of the Top Quark", but nowhere in the paper is the previous measurement quoted, and so one cannot easily compare the new result with the old one, as the title invites the reader to do.

Done.

Para 3

(line 1) "dilepton" is not defined until Para 6, but is used here. Move the definition from Para 6 to here (and move the reference position to make room for the definition): "The new method is similar to one suggested [9] for ttbar dilepton decay channels (where both W bosons decay leptonically), and used ..."

Done.

Para 4

(line 3) Move the second half of the parenthesis up, I think: "(0.025 E + 0.5) GeV."

Nope, as units of energy are not specified here. No change.

(line 6) The references are in the wrong order at the end of the paper. Here is [14] but we have not yet had [11], [12], or [13].

Thanks for spotting this! Reordered the references.

Para 5

(line 1) Leave a space between "\pm" and "3.9"

Done.

(lines 2 and 3) What is written here (as in the PRL draft) is not, I believe, correct. What it says is that the new method is equivalent to 3.4 times as much data (100% of the original data and 2.4 times more, added together.) I doubt this is what you intend to say. (If it is, then replace 2.4 with 3.4 in the following new sentence). To be accurate, you should write: "is equivalent to collecting 2.4 times as much data." (You can find a very nice explanation of this common mistake at http://www.theslot.com/times.html .)

Changed to:

The improvement in statistical uncertainty over our previous measurement is equivalent to collecting a factor of 2.4 as much data.

Para 6

(lines 1 and 2) Omit the definition of "dilepton". It should be in Para 3 (see above).

Done.

In the displayed result, sys -> syst (to match the notation 9 lines above and elsewhere)

Done.

(line 5) standard model -> Standard Model (to match the convention followed in the abstract and elsewhere)

This sentence has been rephrased and does not refer to the SM anymore. The last sentence now reads:

This result corresponds to the most accurate measurement of the top quark mass in any single experiment and shifts the value of the expected Higgs mass to ≈ 125 GeV/c^2 (see Figure~\ref{fig:blueband}), which is consistent with the experimentally excluded range and still can be accessed in the current run of the Tevatron and at future runs at the Large Hadron Collider.

(line 7) LHC -> Large Hadron Collider (the Nature audience may not all be HEP afficionados)

Done.

Para 7

This paragraph is a 7-line sentence. It would read more easily if it were split into two sentences without the subclauses:
"The new method for extracting the mass of the top quark provides substantial improvement in both statistical and systematic uncertainties.
This can be attributed primarily to the fact that: (i) each event now has ... , and (ii) all jet and neutrino combinations ..."

Good suggestion! Point taken.

(line 5) extraction of top mass -> extraction of the top mass

Done.

Para 11

(line 4) incident quarks [13] -> incident quarks with momenta q1 and q2
[13] (the q's are not defined anywhere. It could be that one should have defined them earlier, in Para 8 where they are first used, instead of here. But they should be defined somewhere.)

The sentence has been rephrased. It now reads:

… and $f(q)$ are parton distribution functions that reflect the probability of finding any specific interacting quark (antiquark) with momentum q within the proton (antiproton).

(line 7) MC -> Monte Carlo (MC) (it has not been defined anywhere yet)

Done, except that the first mentioning of MC was much earlier, so it's defined there.

Para 13
---

was defined -> is defined (to match the tense of the other paragraphs
nearby)

Done.

Para 14

(lines 3, 4, 5) This sentence, with its subclauses, is hard to follow. I recommend splitting it: "These integrals are calculated using MC methods.
The best value of Mt represents the most likely mass of the top quark in the final N-event sample, and the parameters ci reflect the amount of signal and background. Mt and ci are defined by minimizing ..."

Done except for defined -> obtained in the last clause.

Para 15

(line 2) passed -> pass (to match the tense of the paper)

Done.

(line 2) for the above top mass bin -> for the top mass bin

It's bias, not bin, and we felt that referring to the fact that it has been defined in the previous paragraph would remove any ambiguity. No change.

(line 3) was maximized -> is maximized

Done.

Yet again, thanks so much for beautifying the figures for this paper. I trust that Juan and you working together have addressed most of your concerns below.

Figure 1

The color for the gluons shows up as ~1% gray-scale on a b/w printer, so they are essentially invisible. Could a darker shade or color be selected so the paper doesn't need to be printed in color only?

I think "(a)" and "(b)" look more elegant that "a)" and "b)" as labels, and then they match the text notation in the caption and in the main text.

In the text, particles are all in italics. The particles in the figure should also be in italics.

In the caption, there is a similar problem to the "2.4 times more" one of the text. At the moment, the caption says that 90.9% of the rate is from qqbar and 9.09% from gg. I think this is not what you intend to say. I remember a higher fraction of gg at 1.96 TeV for example. Scanning

hep-ph/0308222 I can't find a recently calculated fraction, one needs to integrate the curves in Fig 3, p 15 for example. They note in the text that the qq fraction went up a lot for the NNLO pdf w.r.t. CTEQ5M, but that the gg fraction did not change, and so perhaps it really is only ~10% gg even now. Anyway, whatever number is the correct one, the wording is ambiguous, and should be changed to read "Diagram (a) (quark-antiquark
production) is dominant, but diagram (b) (gluon fusion) and related diagrams contribute \approx 10\% to the cross section." (i.e., omit "an additional").

Figure 2

The shading for the excluded region is invisible on a b/w printout. Choose a darker shade?

I think that "Preliminary" will not be needed once the paper is submitted.
The font size is too large as it lies slightly over the dashed line. It should be in italics to distinguish it from the "Excluded" which is part of the information about the content of the plot (which "preliminary" is not).

Remove the ticks from the top axis. Only one is visible and it looks strange on its own.

The x-axis needs more than one number on it. I suggest labeling "20 100
200"

The x-axis label units do not match the text notation (add the c^2):
[GeV/c^2]

The x-axis brackets should be rounded to match those used in Figs 3 and 4.

MH in the x-axis label should be in italics.

Caption: (line 3) blue band -> blue band around it (helps those who
printed the paper in b/w)

Figure 3

The figure is dominated by empty space which is not very interesting. I would suggest changing the aspect ratio so it is wider than tall, although that helps only a little. It does not affect the ratio of information to empty space in the figure, but improves the ratio of empty space to text density in the caption and text.

Put the data points on top of the histograms. (There are several ways to do this.)

Move the axis labels out slightly from the axis numbers, especially on the y-axis. At the moment there is an overlap.

Events/bin -> Events / 0.05 bin (note the spacing as well as bin size)

Figure 4

Perhaps make the aspect ratio of this figure match the (new) one for Figure 3. It takes up a large vertical space with not much information in it at the moment relative to its shape.

Move the axis labels away from the axis numbers as for Fig 3.

Dear Ulrich,

Thanks a lot for detailed comments! The general comment (10) is addressed in a separate statement; please find the reply to your other comments embedded in the text. It appears that you have commented on the private version of 12/24 sent only to the EB and people directly involved in drafting the paper. The official version of 12/29 that went for collaboration comments has some minor editing and thus some of your comments have been already incorporated in the new text.

Greg

From: Ulrich Heintz [heintz@bu.edu]
Sent: Sunday, January 04, 2004 3:43 PM
Subject: RE: Nature draft for group/collaboration review

Dear all,

Happy New Year!

I have read the draft of the paper for Nature and I have a few comments below. It reads well and most comments are minor. Comment 10 is probably the most important.

Regards,

Ulrich

1) page 1 bottom "W" should be in italics.

Done.

2) page 2 top: "For example, in **a** large class...", "(**a** theoretically preferred..." (add the "a"'s).

Already fixed in the 12/29 version.

3) page 2 second paragraph: I don't know what "incident energy" means - how about "center of mass energy"? This whole sentence with the gold-antigold seems contrived. How about: "The center of mass energy of the collisions of 1.8 TeV (...) is almost as large as the rest energy of ten gold nuclei."?

Excellent suggestion! Taken, with the exception “The c.o.m. energy” – c.o.m. is probably jargon to Nature crowd. The sentence now reads:

The total energy of 1.8 TeV released in a head-on collision of a 900 GeV p and 900 GeV $\bar p$ is almost as large as the rest energy of ten gold nuclei.

4) page 2 middle: "those events where..." -> "those events in which..."

Done.

5) page 2 3rd paragraph: "The critical differences from the previous analyses **of ttbar events** are:..." This would address Gaston's concern whether this comparison is with Dalitz and Berends

or with previous top mass analyses. I think there is general agreement that a) is a crucial point, but I am not so sure it has been demonstrated that
b) is correct. I believe there also is another critical difference:
requiring exactly 4 jets reduced the sensitivity to the modeling of gluon radiation.

The requirement of exactly four jets is part of (b), as this is a way to reduce combinatorics. The sentence has been changed slightly in 12/29 version to address Gaston comment. The ambiguity has been eliminated by explicitly stating that the differences are compared to previous measurements,

6) page 2 a bit further down: "missing energy" -> "missing (transverse) momentum" - we cannot measure the energy of the neutrinos, only their momentum. As far as I remember the missing momentum was not used in the analysis.

Done.

7) page 2 still in the same sentence: "due to the ambiguity in choosing the two quark jets that correspond to the W decay" doesn't quite state the issue correctly and unambiguously. It could be understood to mean that there are two ways to assign jets to the q and qbar from the W, which is totally irrelevant. Further there is an ambiguity between the b and the bbar that this does not mention. So how about: "due to the ambiguity in choosing the jets that correspond to the b and bbar quarks from the decays of the top and antitop quarks."?

Excellent suggestion – done.

8) page 3 top: "The other contributions..." -> "All other contributions..."

Done.

9) page 3 2nd paragraph: "The analysis is also less sensitive to the JES, **which** leads to...". replace "and" with "which". Replace "the two uncertainties" with "statistical and systematic uncertainties". Drop "the" in "comparable to all the previous...".

First point taken; the other two have been already taken into account in the 12/29 version.

10) page 3 3rd paragraph: "This result is more consistent with expectation from the SM..." - more than what? If I look at the EWWG summary from summer 2003, I see m_top=172+12-9 GeV when the Z pole data are used, and m_top=179+11-9 GeV when also the W mass and width are used. The previous world average for the top mass is 174.3+-5.1 GeV, now D0 has 179+-5.2 GeV.
I think this statement just lacks any scientific basis - there is not one unique prediction for m_top from the standard model and the improvement in the agreement is at best half a standard deviation - nothing to write home about. - Frankly - if publication in nature depends on hyping half sigma effects I wonder whether it's the right place to publish for us.

See separate reply to this concerns.

11) page 4 top: first word: replace "that" with "the". I believe, the analysis does not take into account the gluon fusion contribution to ttbar production, this sentence should read: "...specific interacting quark with momentum q within the ...".

Good eye! Replaced with: "… probability of finding any specific interacting quark (antiquark) with momentum *q* within the proton (antiproton)." First point has been already addressed in the 12/29 version.

12) page 4 2nd paragraph: how do the transfer functions take into account merging and splitting of jets? They are derived by matching partons and jets. When there is hard gluon radiation that splits the jet into two, neither jet may match the original parton and such extreme events can therefore not be used to derive the transfer functions. This is not necessary, because the event selection eliminates events in which a jet split or two jets merged. Remove the reference to splitting and merging.

Indeed, the transfer function does not model hard gluon radiation, it will only model the soft radiation (radiation that does not produce an extra jet with Et>15 GeV). The transfer function does not model the merging of the products of two partons into one jet either. Reference to splitting and merging has been removed.

13) page 4 3rd paragraph: Instead of stating that we ASSUME that the jet angles and the electron energy are measured perfectly, it might be better to state that jet angles and electron energy are well measured and that resolution effects are dominated by the jet energy resolution.

Good point. The sentence is changed to:

Since the angular directions of all the objects in the event, as well as the electron momentum are measured with high precision, their measured values are used directly in the calculation of the probability that any event corresponds to $t \bar t$ or background production. To account for a measurement uncertainty due to imperfect muon momentum resolution, the known momentum smearing function~\cite{muon} is used.

14) page 5 top: drop the "in" after 10^{-11}. Replace "the" with "a" at the beginning of the last sentence in the first paragraph: "A total of
22 data events...".

Already fixed in the 12/29 version.

15) where are the acknowledgements?

Thanks for spotting this! The standard acknowledgement paragraph is added in the new version.

16) I agree with Sijbrand that we should add "D0" on all figures - and remove the "preliminary" from figure 2.

Ann Heinson has kindly done this for us.

Ulrich Heintz
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Dear Ron,

Thanks for the comments! See replies, embedded in the text.

Greg

From: Ron Madaras [RJMadaras@lbl.gov]
Sent: Wednesday, January 07, 2004 12:48 AM
Subject: Nature draft

I think it is a good idea to send this to Nature. I assume that is not a problem with PRL?

Thanks! The plan is to submit this to Nature and then work with PRL on publishing more detailed PRL draft. A lot of effort went into decoupling the Nature paper from the PRL draft in content, so we hope for publication in both journals.

The format is odd, for me, since I'm used to having the final results at the end, and not in the middle of the paper. Is this the way the Nature editor wants it?

Yes, this is exactly what has been recommended by the editor. Nature articles often put details of measurements in a separate section rarely read by anyone else, except for the professional in the given field.

I really liked the last sentence in the PRL: "This is the best measurement of the top quark mass in any single experiment." Could you please add it to this paper?

Done, see reply to your next comment.

On p.3, when you say that this result shifts the expected H mass to 125 GeV and "which can be accessed in the...Tevatron...and LHC", it gives the impression that the previous value of the expected H mass could not be accessed at the Tevatron or LHC, but this is wrong, since the previous value was smaller than 125 GeV. This wrong impression should be corrected.

The sentence in questions has been changed to:

This result corresponds to the most accurate measurement of the top quark mass in any single experiment and shifts the value of the expected Higgs mass to ≈ 125 GeV/c^2 (see Figure~\ref{fig:blueband}), which is consistent with the experimentally excluded region and still can be accessed in the current run of the Tevatron and at future runs at the Large Hadron Collider.

Ron

Dear Martijn,

Thanks for your detailed comments! I do feel that you significantly misinterpreted the main goal of this paper, as well as the intended audience of Nature. It's always hard to try to figure out what other people would think after reading your paper, however you are thinking about a particle physicist reading the article, not a biologist (or someone similar – the major audience of Nature). Not only these people have no idea of previous measurements; some of them might be even puzzled to learn that top quark exists. We are doing something very new here, so we need to change our ways of perception and learn to cater to more general auditory. This is what the paper is supposed to achieve (with a great help from a Nature editor). It shows the importance of precision measurements and ever increasing precision, using the Higgs sensitivity to the value of top mass as an example.

Martin has already replied you with corrections to some of the assumptions that you made; I am not going to repeat his reply here. I'd like to refer you to a preamble to the collaboration comments, which addresses some of the fundamental issues you raised, as well as to reply to your specific comments, embedded in this text.

Best regards,

Greg

From: mulders [mulders@fnal.gov]
Sent: Thursday, January 08, 2004 12:51 PM
Subject: Comments on Top Mass Paper for Nature

Dear Top mass authors,

Allow me to give my opinion about the Top Mass draft for Nature. In general I think this is going to be a very good article. But I do have some strong feelings about its fundamental message. Sorry for giving comments so close to the deadline. My feedback was delayed by holiday activities. I am planning to sent a few more superficial, detailed comments tonight, and will be at Fermilab tomorrow from 8 am onwards for discussion.

It is very cool that we have an opportunity to publish in Nature. I also think it is potentially dangerous. It does not happen very often that a re-analysis of the same data is worth a publication in Nature all by itself. We have to make very clear what the true reasons are.

Sorry, but: no guts, no glory…

I think that the current draft contains too much emphasis on the existence of a 'problem' in the Standard Model and the fact that the new result 'fixes' this by shifting the measured mass to a somehow more desirable value. We have to be very careful not to create the impression that we are biased and that our reasons for publishing a new result are un-scientific.

The claim made in the PRL (which I believe is correct) is that the new and the old measurement are statistically compatible, albeit at an O(2 sigma) level... There is no way we can know which of the two measurements is closer to the 'true' value and which is subject to a statistical abberation. For all we know both measurements are 'correct'. And we know that the new measurement has a

much smaller statistical uncertainty. But to decide which one is somehow more desirable would be wishful thinking.
The fact that a statistical fluctuation in one measurement can lead to such a significant shift in the 'most likely' value of the Higgs boson is remarkable. It is a refreshing wake-up call for those people who had been looking too much at the Blue-Band plot and forgot the meaning of a 1-sigma statistical uncertainty. Statistical fluctuations do happen after all !

The content has been softened somewhat. Nevertheless, many people got carried away with “one-sigma” effects soon after the 115 GeV LEP Higgs saga was over. It’s our goal to rebut these misleading papers.

The problem with stressing the percieved 'problem' in the Standard Model is the following: the logical conclusion from this line of thought is that there WAS an inconsistency in the Standard Model fit, and that it was solely caused by an ERRONEOUS Top Mass measurement published by D0.
Somehow we wriggle our way out of this with a new, complicated method that gives a result that is 'more compatible' and now the Standard Model Fit is saved. And we don't reveal what the real problem was with the old measurement... That would be a very negative and incorrect conclusion!

I understand that the Nature publishers would like to have some fireworks in their magazine, but let's resist the temptation to fall in the very same trap that was uncovered by this new Top Mass result! I think the true conclusions from the new measurement are much more exciting:

* By doing a smarter statistical analysis we are able to improve our sensitivity by a factor 2 compared to our published analysis, which was state-of-the-art only a few years ago. That is absolutely remarkable!

* And by-the-way, if some people were starting to get uncomfortable by the perceived tension between the Standard Model Fit and the direct searches for the elusive Higgs Boson, this single result single handedly proves them wrong by shifting everything to a different value. This is very good news for them and a refreshing reminder for others.

* The real point that we should stress is that this shows clearly how little our knowledge is about the Top quark and how big its effect is on the Standard Model Fit! It is absolutely crucial to learn more about the Top quark and that is what D0 is going to give us in the immediate future.
The good news is that in fact we already have a large set of new data and vastly improved analysis methods!

The points you made are valid, but they don’t click with the Nature stuff. We tried all of them in our multiple communications with the editor, just to receive a cold shoulder. They are looking for something understandable and exciting for broad auditory of scientists; the state of the SM carries such weight; somewhat higher precision of A measurement does not.

To conclude, I think it is really important that we change the fundamental message in this article. The good news is that this can be achieved by changing just one or two sentences and polishing a few words here and there. All the scientific, technical information is already in place.

We hope you’d like the changes we made. Several sentences have been softened, which hopefully addresses your concerns.

Cheers,

Martijn

From: mulders [mulders@fnal.gov]
Sent: Thursday, January 08, 2004 11:53 PM
Subject: Comments on Top Mass Paper for Nature (part II)

Hello again,

As promised a few more detailed comments on the draft:

Page 1, line 4: "In particular, the masses of the top quark (Mt) and of the W boson (Mw) constrain the mass of the hypothesized Higgs boson" --> On the contrary... one could argue that these two masses constrain the Higgs boson mass LEAST of all the relevant measured quantities. Their current uncertainty dominates the uncertainty on the indirect prediction of the Top mass. That is why measuring them more precisely will have such a large impact on our prediction of the Higgs mass.

See Martin's reply to you on this point.

Page 1, line 9: "A pressing problem for the SM" --> I don't think we can claim that there was a 'problem' with the SM without seriously undermining the credibility of our own published results (see my previous email).

Sentence has been softened: "A potential problem…"

Page 1, line 10: "presently accepted mass of the top quark" --> idem, suggests that our previously published results will no longer be 'acceptable' after reading this article.

Nope, it merely has been superseded with a consistent, but more precise measurement. Happens all the time. Besides, we refer not to our previous result, but to the world average.

Page 1, line 18: "... a value more consistent with the SM." --> a puzzling conclusion. Isn't the Higgs mass one of those parameters that is not directly predicted by the SM ? (see the first sentence of the
paper) How then can one value be more consistent with the SM than another value?

Point taken; the sentence has been changed. "more consistent with experiment…"

To accommodate the above comments, one would have to rephrase and reorganize the first paragraph a bit. Something like (?):
"[keep the first sentence]. In particular, the mass of the hypothesized Higgs boson - the last remaining particle predicted by the standard model that has not yet been observed - can be constrained by a global fit of the Standard Model including all quantities that have been measured in experiment. Such a fit, using the latest experimental results, predicts a relatively light Higgs boson [reference to recent LEP EW working group fit?]. Similar fits using popular extensions of the Standard Model, including supersymmetry, also predict a light Higgs mass. However, in spite of many experimental searches in the most likely mass region, no conclusive direct signs off the

Higgs boson have been observed so far [2]. It is important to realize that the indirect prediction of the mass of the Higgs particle is extremely sensitive to the mass of the top quark. Direct measurements of the Top quark are therefore crucial. Here we report on a new analysis of the Run I D0 data which dramatically improves the precision on the measured value of the top quark mass and sheds a new light on the Higgs mass prediction.

This section has been largely reworked to address your and others comments. Please, refer to the new text for detail.

Page 2, second half: _excellent_ introduction of the new method! It gives a clear and concise description of the basic idea and (as far as I can
see) correctly identifies the key reasons for the improvement. I like the idea of postponing the detailed description to a seperate section in the end.

Thanks – that was actually an editorial suggestion.

Page 2, 13 lines from bottom: ", and akin to an approach suggested for the measurement of the mass of the W boson at LEP [10]" --> As I already commented to the PRL draft (see forwarded email below) and discussed with Juan and Gaston I think this is a silly reference. Better references are available. I would propose to replace the above quote by ". The analysis combines ideas suggested [10] for and used [10b] in the measurement of the mass of the W boson at LEP.".

[10b] MEASUREMENT OF THE W PAIR CROSS-SECTION AND OF THE W MASS IN E+ E-
INTERACTIONS AT 172-GEV.
By DELPHI Collaboration (P. Abreu et al.). CERN-PPE-97-160, Dec 1997.
24pp. Published in Eur.Phys.J.C2:581-595,1998

We opted to use the same reference as the PRL uses after the collaboration review. No change, sorry.

Page 3, 1st line below Mt equation: leave out " is more consistent with expectations from the standard model, and"

Sentence has been changed accordingly, see text.

Page 3, 1st paragraph of "Top Mass Extraction": as I already commented to the PRL draft (see below) I don't believe this explanation is entirely correct. Since you have already given an excellent explanation of the key elements of the improvement on the previous page I propose to leave out the entire paragraph "The new method ... contribute to the measurement".
One could start this section just with a general reminder of the basic approach used, like "The new analysis is based on a likelihood that is calculated for each event taking into account all jet permutations, the probability that the event was signal or background, and the resolution of the D0 detector"

The sentence has been somewhat rephrased, but is left in. We might have to cut this section anyway, if the paper is too long; will use your suggestion then.

Page 4, 1st line below equation: use same font consistently for matrix element "M" (different from font used for the top mass "M")

Good point, corrected.

Page 5, second paragraph "A discriminant D = ... signal from background."
--> please start this paragraph with "To illustrate the power of
discrimination... " so that the reader knows immediately that this is not actually used in the analysis and does not start out on the wrong footing.

The sentence now starts with:

To illustrate the separation between the top signal and background, a discriminant…

Page 5, 1st line below equation: "MC methods" --> "MC integration methods"
to distinguish this from other "MC" applications used elsewhere.

Done.

Figure 2: I understand the motivation for showing this plot, but I believe it is meaningless in its current form. To compare the old 'All data' with the 'new D0 only' does not prove anything. By leaving out arbitrary measurements from the world average you can shift this curve anywhere you want. Is there really no way to include CDF in the fit with the new D0 measurement? If not one should at least include a 3rd curve: 'Old D0 only' to have a comparison between two equivalent data sets... that should also nicely illustrate that a larger error on the Top mass results in a wider parabola (right?) ...

You have misinterpreted the plot. The dashed curve is not DØ only, it also corresponds to all data, except for the new DØ top mass measurement instead of the old world average. The only thing that has been removed is the CDF top measurement, as we have not combined our new measurement with them yet. Since our measurement is more precise, the CDF measurement does not change the average significantly. Legend has been updated to make it less ambiguous.

Caption of Figure 2: I propose to remove the sentence "The improved top mass measurement eliminates the previous conflict between the most likely value of the Higgs mass and experimental excluded masses.". The plot speaks for itself, and leaves it up to the reader whether or not he/she sees a previous conflict.

Caption has been changed to soften this message.

Cheers,

Martijn

Dear Arnulf,

Thanks for your comments! Please, find the replies to specific points you raised, embedded in the text.

Best,

Greg

From: Arnulf Quadt [quadt@fnal.gov]
Sent: Saturday, January 10, 2004 6:51 PM
Subject: comments on Top Mass paper for Nature

Dear all,

having read the Nature draft of the top mass paper I still believe it's a very good analysis and we should publish it either way asap.

I have a few comments on the text appended.

Best regards,

Arnulf

- introduction: 'pressing problem' ...
it's not pressing, it's within the errors. Also the aim of this analysis is not to solve this `problem', but to improve the prescision of the analysis. The increase in the extracted m_top is just a by-product. Would you not want to publish if m_top had come out to 175 GeV ?

Sentence has been softened. “Potential problem…” Your point is correct, but sadly, I am afraid that Nature would not have accepted our paper if the new top mass was 175 GeV. In a sense, the Nature article itself is a byproduct of the change in the top mass. We believe that the implications of this change show how sensitive the SM is to the top measurement and thus how important is to improve precision further. This is the selling point for Nature.

- introduction, ref [2]:
This reference should be:
The LEP Collaborations ALEPH, DELPHI, L3 and OPAL, the LEP Working Group for Higgs Boson Searches, Search for the Standard Model Higgs BOson at LEP, CERN-EP/2003-011, Phys. Lett. B565(2003) 61-75.

Reference added.

- m_H estimate from 96 to 125.
This should be reference with [2] since these numbers do not come from a D0 analysis, in particular they do not come from the top mass analysis.

Done for 96 GeV; 125 comes from Martin, who is a member of DØ.

- p.2 m_h limit of 135 GeV in MSSM. -> add references, for example
  Y.Okada, M.Yamaguchi and T.Yanagida, Prog.Theor.Phys. 85(1991)1
  J.Ellis, G.Ridolfi and F.Zwirner, Phys.Lett. B257 (1991) 83
  H.E.Haber and R.Hempfling, Phys.Rev.Lett. 66(1991) 1815
  M.Carena, J.R.Espinosa, M.Quiros and C.E.M.Wagner,
  Phys.Lett.B355 (1995)209
  M.Carena, M.Quiros and C.E.M.Wagner,Nucl.Phys. B461 (1996) 407
  H.E.Haber, R.Hempfling and A.H.Hoang, Zeit. f\"ur Phys. C75(1987)539
  S.Heinemeyer, W.Hollik and G.Weiglein, Eur.Phys.Jour. C9(1999)343
  J.R.Espinosa and R.Zhang, Nucl.Phys.B586(200)3

I am afraid that adding so many references would certainly put our paper above the page limit. This is really a public domain knowledge, so we prefer not to give a reference here. We do not give reference to supersymmetry either.

- p.3, l.17
  ... expect Higgs mass to a region ~125 GeV -> add reference [2].
  this is not a D0 analysis.

See above; according to Martin, no special reference needed. We already said that this value has been obtained using methods [2].

  l.22 ... can be primarilty attributed to:
  -> add `the fact' or something so that sentence gramatically
    can be continued with 'that ...'

Done.

  l.25 ... likeliest -> most likely

Done.

- p.4 bottom line: HERWIG -> add reference

Done.

- p.8, Figure 1:
  For Nature audience tt production might be sufficiently described
  and more attractive to use pictures along the lines of:
  http://www-clued0.fnal.gov/~quadt/anim_top/top10_1.jpg

We started with a similar figure, but have been asked to switch to a Feynman diagram instead by the editor. Puzzled me too…

  Differences between gg -> tt and qq -> tt are not refered to in the
  text.

Not exactly sure why they should be? Please, clarify.

- p.9, using the procedure of Ref.[2]
  -> it should be clearly stated that this is a result of the LEP-EWWG
     with ref[2], and not a D0 result
     dashed line does not have +-5.2 GeV error for new m_top.

See above.

  Again we give the impression that this is a D0 result. It's from the
  LEP-EWWG and was not done in the context of D0, not shown/discussed
  ... in the collaboration ... -> given reference to [2]/

See above.

- p.10 -> add legend to plot itself, description in caption not
          sufficient.

- p.11 -> add legend to plot itself, description in caption not
          sufficient.

Figures have been improved.

--
Best regards,

  Arnulf

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Dear Gerard,

Thanks for your comments and compliments! Please, find the replies to specific points you raised embedded in the text.

Best,

Greg

From: Gerard Sajot [sajot@in2p3.fr]
Sent: Friday, January 09, 2004 9:24 AM
Subject: comments to : Improved precision on the mass of the Top..

Dear Colleagues,
I appreciated very much reading the draft version to be submitted to Nature and in particular the consequence of the new top mass measurement on the most likely value for the Higgs mass (in my opinion this has to be added to the PRL draft too).
I just have minor comments :
I_ Abstract
Readers which will read only this part (a minority I hope!) should get all the informations to understand the impact of this improved mass top measurement.
1- the name Tevatron and Fermilab should appear in this part

Good point, the following sentence has been modified to reflect your suggestion:

Here we report a determination of the top quark mass of $\bm{M_t=180.1 \pm 5.3}$ GeV/$\bm{c^2}$, using a new method of analysis performed by the D\O\ Collaboration at the Fermilab Tevatron proton-antiproton collider.

2- I suggest to replace "....the most likely value of the Higgs mass lies in a range that has already been excluded by experiment ref(2)"
by something more precise like :
....the most likely value of the Higgs mass (96 GeV/c2 ref 2) lies in a range that has already been excluded by LEP experiments (lower Higgs mass limit 114.4 GeV/c^2 at 95 % CL ref XXXX)

This part has been changed significantly; the excluded region is well shown in Fig. 2 as well.

And then one can simplify the last sentence:
"...by more than 30%, from 96 GeV/C^2, which is in the excluded region, to around 125 GeV/c^2.."
--> "...by more than 30%, from 96 GeV/C^2, to around 125 GeV/c^2..."

This part has been changed significantly; see text.

If I am not wrong the ref XXXX quoted above is
"Search for the Standard Model Higgs Boson at LEP"
ALEPH, DELPHI, L3 and OPAL Collaborations
The LEP Working Group for Higgs Boson Searches

CERN-EP/2003-011 April 25, 2003
hep-ex/0306033

Incidentally I succeeded only to get the first 36 pages of
ref 2 : hep-ex/0312023! (I tried all the formats proposed!)

Reference to direct Higgs searches has been added. Strange – I had no troubles getting the entire indirect limits paper.

3- why not add the value and the ref for "... than the previous world average? (This value 174.3 +- 5.1 GeV/c^2 is quoted in caption fig 2 but without any reference)

Our own previous measurement has been quoted instead.

II _Figure 1:
a \bar q is missing in diagram a)

Figures have been improved.

II_ Caption Figure 2
I suggest to add "(114.4 GeV/c^2 at 95% CL with reference)" after "...and experimental excluded masses."

Good idea – done.

Best regards. Gerard

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Dear Stefan,

Thanks for the comments, and apologies for a short notice on the Nature paper: the situation with the editors evolved very quickly and since we need to publish our new measurement very soon in order to be able to combine it with CDF in time for Moriond, the time-frame for comments has been set rather rigid. The analysis itself has been already approved by the collaboration in the form of PRL, so the comments on the Nature paper have been expected to be mainly stylistic.

We understand your concern about the main point in this paper and have addressed it in a separate statement, included as a preamble to the replies to comments from the collaboration. Several sentences that you questioned have been changed to avoid misunderstanding. We hope that you would like the new version and find it closer to your vision.

As a side remark, it's very dangerous to try to interpret a paper from the point of view of somebody outside the field. I believe that you have grossly overestimated the curiosity and background of an average Nature reader; this is precisely why we chose to trust the editor on such issues.

Best,

Greg

From: soldner [soldner@fnal.gov]
Sent: Sunday, January 11, 2004 5:18 AM
Subject: Run I Top Paper

Dear Colleagues,

I had overlooked the news message announcing the Nature draft, so my comment is coming a bit too late. In this context I think that is not good practice to invite comments from the collaboration on Dec. 29 with a deadline Jan. 9, in the middle of the holiday period. This is especially true for a case like this where a paper is submitted to Nature which obviously is a break with standard procedures.

I will limit my comment to a single issue which is related to the sales pitch of the paper. I find it highly problematic to construct a discrepancy in the SM due to the fact that the best SM fit for the Higgs mass with the old top mass is below the 95% CL exclusion limit. I understand, of course, why this was done.

Nature is read by many by non-particle physicists and scientist who have little knowledge of electroweak fits, their input and the statistical methods used.

The way the paper is written is bound to lead to misunderstandings, as a science journalists I would (mis-)interpret the article in the following way:

> Scientists at the D0 experiment at Fermilab recently had
> to revise their previous result for the measurement of the top
> quark mass. Previous measurements showed that the Standard Model
> of particle physics was not correct because the measurements
> predicted a mass of the 'God particle', the Higgs Boson, lower

than what has already been excluded by experiments.
The revised top mass measurement now comes to the rescue
of the Standard Model.

..or something like that..

Anyway, it must be clear that having the best Higgs mass below 115 GeV is perfectly consistent with the SM and that moving the top mass up by 1 sigma is not changing anything concerning the (in)-consistency with the SM.

I am not a Run I physicist but I still hope you find my comment useful, I would be interested to hear the opinion of our electroweak experts (Marco&Terry) on this, so I cc:ed the message to them.

cheers

Stefan

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Hi Darien,

Thanks for attentive reading and the comments on the Nature draft. Several people have commented on the fact that we use the shift in the Higgs mass as a key point in this paper. This was a result of long series of attempts to make our paper attractive to Nature audience and we have summarized this in a separate comment, which preludes our replies to specific comments from the collaboration. In a nutshell, we believe that this is an important point to make, and, alas, this is the only point that interested Nature people. We have softened the sentences you questioned somewhat, so hopefully our claims do not look outrageously statistically. Figure 2 is put in the paper specifically to demonstrate the statistical significance of the changes.

As to the suggestion to use Fig. 1a of the PRL instead of 1b, the idea was to decouple the Nature paper from the PRL as much as possible, with the goal to publish both. We believe that Fig. 1b is less important to keep in the PRL as Fig. 1a, precisely for the reasons you mentioned. This would be the first figure to sacrifice from the PRL if editors insist that the two papers have large degree of similarities; it would be also the natural figure to cut from the Nature paper if it appears to be too long.

I'd like to refer you to the new draft of the paper and the general comment and hope that you like the new version more than the draft you read.

Best,

Greg

From: darien@neu.edu on behalf of Darien Wood [darien@neu.edu]
Sent: Friday, January 09, 2004 12:24 AM
Subject: comment on Nature draft on top mass

Hi Juan, et al.,

Hi,

This is a really beautiful and elegant analysis, and in principle I like the idea of publishing in Nature.

In general, the paper reads well, but I am bothered by the emphasis on the shift in the most likely value of the Higgs mass. In three places, this shift is highlighted in the text

p. 1: "...from 96 GeV/c2, which is in the excluded region, to ~125 GeV/c2, a value more consistent with the SM."
p. 2: "This result is more consistent with expectations from the standard model, and shifts the value of the expected Higgs mass to a region of ~125 GeV (see Figure 2), which can be accessed in the current run the the Tevatron and a future runs at the LHC."
caption to Fig 2: "The improved top mass measurement eliminates the previous confict between the most likely value of the Higgs mass and experimental [sic] excluded masses."

The first statement is true, since it states simple facts about the most probable value, but it is misleading since there is little statistical significance in this shift. From fig 2, you can see that the Delta-chisq for 125 GeV was less that 0.5 for the old curve.

The second statement talks about a shift in "the expected Higgs mass", which I would normally expect to refer to the expected range, and not just to the most probable value, so again it seems to make a stronger statement than is justified statistically.

The third statement refers to a "conflict", which again can be seen from the figure to be less than 0.5 in Delta chisq. Is the word "conflict" is used instead of "inconsistency" because we can't justify calling it an inconsistency?

I would be happy with one statement to the effect that the direction of the shift in top mass goes in the direction of heavier Higgs mass. But it would be more scientific to quote number with errors or ranges instead of just most probable values. I think it is also nice to include Fig 2, because that really displays the whole situation both qualitatively and quantitatively. But I feel that we look like theorists if we talk about changes in central values without respecting the uncertainties.

That is the end of the rant on Higgs mass shift.

I have one more suggestion. I liked 1 (a) in the PRL draft. I would prefer to see this figure replace Fig 3 in the Nature draft. Although Fig 3 gives some feeling for the discrimination between signal and background, the figure (and the discussion of the discriminant on p. 5) seem like an aside, since the discriminant is not actually used anywhere in the analysis.

- Darien

Hi George,

Thanks for your comments on the paper! Many of your proposed English corrections are incorporated in the new draft, most importantly the change in title. The bold paragraph is the only thing read by many Nature readers, so the editor advised us against short-hand notations there. Similarly, we opted to keep “top quark mass” instead of Mt in many places in the text to make it read easier.

Your question about possible dependence of A(x) on Mt has been answered by Gaston:

“Yes, it is true that A(x) is independent of Mt. This is always true. The detector never knows what produced a given final state. Given a configuration of particles which we label with x (for example an electron and 4 jets) the acceptance will only depend on how that particular configuration looks like. That same configuration could come from top, w+jets, or any other known or unknown phenomena, as long as the final configuration is the same (and that is what we label with x) the detector would not be able to tell the difference.”

Best,

Greg

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on The Top Quark Mass Measurement

not a great title

Improved Precision ~~on the Mass of the Top Quark~~

adopt one phrase for SM and M_t and use consistently?

The DØ Collaboration

[Full list of authors to be inserted here]

29th December 2003

The Standard Model (SM) of particle physics ~~contains~~ includes about two dozen parameters – such as masses of quarks and leptons – whose origins are still unknown and cannot be predicted within the ~~Model~~ SM, but whose values are constrained through their interactions. In particular, the masses of the top quark (M_t) and of the W boson (M_W) [1] constrain the mass of the hypothesized Higgs boson – the last remaining particle predicted by the ~~standard model~~ SM that has not yet been observed. A light Higgs particle is expected in several popular models, including supersymmetry. Indirect constraints on the mass of the Higgs particle are extremely sensitive to ~~the top mass~~ M_t. A pressing problem for the SM is that, based on the presently accepted ~~mass of the top quark~~ M_t, the most likely value of the Higgs mass lies in a range that has already been excluded by experiment [2]. Here we report a ~~determination~~ measurement ~~of~~ of the mass ~~for~~ the top quark of ~~XXX~~ 180.1 ± 5.3 GeV/c^2, using a new method of analysis. Combined with our previously published measurement of ~~the top mass~~ M_t (in an independent decay mode) [3], this yields $M_t = 179.0 \pm 5.2$ GeV/c^2, i.e., one standard deviation higher than the previous world average. This value corresponds to an increase of the most likely value of the Higgs mass by more than 30%, from 96 GeV/c^2, which is in the currently excluded region, to ≈ 125 GeV/c^2, a value more consistent with the SM.

The observation of the top (t) quark served as one of the major confirmations of the validity of the SM [4, 5]. Of its many parameters, the mass of the top quark, in particular, reflects some of the most crucial aspects of the ~~Model~~ SM. This is because, in principle, the top quark is point-like and should be massless; yet, through its interactions with the Higgs field that ~~supposedly~~ is postulated to permeate our entire universe, the physical mass of the top quark appears to be about the mass of a gold nucleus, or of order 200 proton masses. Because it is so heavy, the top-quark (along with the W boson) provides an unusually sensitive tool for investigating the Higgs field. M_W is known to a precision of $\not<$ 0.1%, while the uncertainty on M_t is at better than

9 Jan 03

the 3% level [1]. Improvements in both measurements are required to restrict further the allowed range of mass for the Higgs. Precise knowledge of the Higgs mass is crucial for our understanding of the SM and any possible new physics beyond it. For example, in a large class of supersymmetric models (theoretically preferred solution to the deficiencies of the SM), the Higgs mass has to be less than ≈ 135 GeV/c^2. If the Higgs turned out to be heavier than that, the existence of low-scale supersymmetry would be essentially ruled out.

The DØ experiment at the Fermilab Tevatron [6] studied a sample of $t\bar{t}$ events produced in proton-antiproton interactions. The total incident energy of 1.8 TeV (900 GeV p colliding head-on with 900 GeV $\bar{p}$) is high enough to yield the equivalent of almost five Au$\overline{\text{Au}}$ nuclei per collision. Each top (antitop) quark decays almost immediately into a bottom b ($\bar{b}$) quark and a W^+ (W^-) boson, and we have re-examined those events where one of the produced W bosons decays into a charged lepton (electron or muon) and a neutrino, and the other W into a quark and an antiquark (see Figure 1). These events and their selection criteria are identical to those used to extract the mass of the top quark in our previous publication [6], and correspond to an integrated luminosity of 125 events/pb. (That is, given the $t\bar{t}$ production cross section of 5.7 pb in $p\bar{p}$ collisions at 1.8 TeV, as measured by DØ [7], these data correspond to approximately 700 produced $t\bar{t}$ pairs.) Information pertaining to the detector and to the previous analysis can be found in Refs. [8] and [6], respectively.

The new method is similar to one suggested for $t\bar{t}$ dilepton decay channels [9], and used in previous mass analyses of dilepton events [3], and akin to an approach suggested for the measurement of the mass of the W boson at LEP [10]. The critical differences from the previous analyses in the lepton plus jets decay channel are: (i) assignment of a higher weight to events that are better measured or are more likely to correspond to $t\bar{t}$ signal, and (ii) better accounting for combinatorics due to several possible assignments of the final-state objects (lepton, jets, and missing energy, the latter being a signature for an undetected neutrino) to the top-quark decay products (e.g., due to the ambiguity in which two quark jets correspond to the $W \to q\bar{q}$ decay). We calculate, as a function of the top mass, the differential probability that the measured variables in any event correspond to signal. The maximum in the product of these probabilities provides the best estimate of the mass of the top quark in the data sample. For details on the new method, see the section on Top Mass Extraction.

In the previous analysis [6], γ+jet events were used to check the jet energy scale (JES)

in the experiment relative to MC simulation. This calibration had an uncertainty of $\delta E =$ ($0.025\ E + 0.5$ GeV). Consequently, all jet energies in our sample were re-scaled by $\pm\delta E$, the analysis redone, and half of the difference in the two rescaled results for M_t ($\delta M_t = 3.3$ GeV/c^2) was taken as the systematic uncertainty in the JES. The other contributions to systematic uncertainty are far smaller [14].

The final result is $M_t = 180.1 \pm 3.6$ (stat) ± 3.9 (syst) GeV/c^2. The improvement in statistical uncertainty over our previous measurement is equivalent to collecting a factor of 2.4 more data. The analysis is also less sensitive to the JES, and leads to a smaller systematic uncertainty. Combining the statistical and systematic uncertainties in quadrature, we obtain $M_t = 180.1 \pm 5.3$ GeV/c^2, which has a precision comparable to all the previous measurements [1] combined.

The new measurement can be combined with that obtained for the dilepton sample (where both W bosons decay leptonically) also collected at DØ during Run I [3], to yield the new DØ average for the mass of the top quark:

$$M_t = 179.0 \pm 3.5(\text{stat}) \pm 3.8(\text{sys})\ \text{GeV/c}^2$$

This result is more consistent with expectations from the Standard Model, and shifts the value of the expected Higgs mass to a region of ≈ 125 GeV (see Figure 2), which can be accessed in the current run of the Tevatron and at future runs at the LHC.

Top Mass Extraction

The new method for extracting the mass of the top quark provides substantial improvement in both statistical and systematic uncertainties, which, as indicated before, can be attributed primarily to: (i) that each event now has its individual probability as a function of the mass parameter, and therefore well-measured events contribute more sharply to the extraction of top mass than those poorly measured, and (ii) that all jet and neutrino combinations (and not just the likeliest one) are included, which guarantees that all events contribute to the measurement.

The probability density as a function of M_t can be written as a convolution of the calculable cross section and any effects from detector measurement resolution:

$$P(x, M_t) = \frac{1}{\sigma(M_t)} \int \mathrm{d}^n\sigma(y, M_t)\mathrm{d}q_1\mathrm{d}q_2 f(q_1) f(q_2) W(y, x) \qquad (1)$$

where $W(y,x)$, our general transfer function, is the normalized probability for the measured set of variables x to arise from a set of nascent (partonic) variables y, $d^n\sigma(y,M_t)$ is the partonic differential cross section, and $f(q)$ are parton distribution functions that reflect the probability of finding any specific interacting parton (quark or gluon) within the proton or antiproton. The integral in Eq. 1 sums over all possible parton states leading to what is observed in the detector. ($\sigma(M_t)$ is the total cross section for producing $t\bar{t}$.)

The impact of biases from imperfections in the detector and event reconstruction algorithms is taken into account in two ways. Geometric acceptance, trigger efficiencies, event selection, etc, enter through a multiplicative function $A(x)$ that is independent of M_t, and that relates the probability $P_m(x,M_t)$ of measuring the observed variables x to their production probability $P(x,M_t)$: $P_m(x,M_t) = A(x)P(x,M_t)$. Effects from energy resolution, merging and splitting of any overlapping jets, etc, are taken into account in the transfer function, $W(y,x)$ (see below).

Our calculation of the probability that any event corresponds to $t\bar{t}$ or background production assumes that the measured angles of all jets and of the electron reflect the exact angles of the top-quark decay products. The energy of electrons is also assumed to be measured perfectly, and the known resolution is used for smearing the muon energy [11]. The integrations over essentially fifteen sharp variables (three components of charged-lepton momentum, eight jet angles, and four equations of energy-momentum conservation), leave five integrals that must be performed to obtain the probability that any event represents $t\bar{t}$ (or background) production for some specified value of ~~top mass~~ M_t.

The probability for a $t\bar{t}$ interpretation can be written as:

$$P_{t\bar{t}} = \frac{1}{12\sigma_{t\bar{t}}} \int \mathrm{d}\rho_1 \mathrm{d}m_1^2 \mathrm{d}M_1^2 \mathrm{d}m_2^2 \mathrm{d}M_2^2 \times \sum_{\mathrm{perm.},\nu} |\mathcal{M}_{t\bar{t}}|^2 \frac{f(q_1)f(q_2)}{|q_1||q_2|} \Phi_6 W_{\mathrm{jets}}(E_{\mathrm{part}}, E_{\mathrm{jet}}),$$

For $|M_{t\bar{t}}|^2$, we use the leading-order matrix element [12], $f(q_1)$ and $f(q_2)$ are the CTEQ4M parton distribution functions for the incident quarks [13], Φ_6 is the phase-space factor for the 6-object final state, and the sum is over all 12 permutations of the jets and all possible neutrino solutions. $W_{\mathrm{jets}}(E_{\mathrm{part}}, E_{\mathrm{jet}})$ corresponds to a function that maps parton-level energies E_{part} to energies measured in the detector E_{jet}, and is based on ~~MC~~ Monte Carlo studies. A similar expression, with a matrix element that is independent of M_t, is used to describe the background processes.

Studies of samples of HERWIG ~~MC~~ Monte Carlo events used in the ~~former~~ previous analysis indicate that

the new method is capable of providing almost a factor of two reduction in the statistical uncertainty on the extracted M_t. These studies also reveal that there is a systematic shift in the extracted M_t that depends on the amount of background in the data. To minimize this effect, a selection is introduced based on the probability that an event represents background from W+jets. The selected value of $P_{\rm bkg} < 10^{-11}$ was based on MC studies carried out before applying the method to data, and, for a top mass of 175 GeV/c^2, retains 71% of the signal and 30% of the background. A total of 22 data events pass this cut.

A discriminant $D = P_{t\bar{t}}/(P_{t\bar{t}} + P_{\rm bkg})$ was defined to quantify the likelihood for an event to correspond to signal at the most likely value of M_t [5]. Figure 3 shows a comparison of the discriminant calculated for data and for MC events. Since the discriminant depends on the top mass, it was not used to reject background and is shown simply to illustrate the level of discrimination of signal from background.

The final likelihood as a function of M_t is written as:

$$\ln L(M_t) = \sum_{i=1}^{N} \ln[c_1 P_{t\bar{t}}(x_i; M_t) + c_2 P_{\rm bkg}(x_i)] - N \int A(x)\,[c_1 P_{t\bar{t}}(x; M_t) + c_2 P_{\rm bkg}(x)]\,{\rm d}x,$$

These integrals are calculated using MC methods, with the best value of M_t, representing the most likely mass of top in the final N-event sample, and the parameters c_i reflecting amount of signal and background, all defined by minimizing $-\ln L(M_t)$. MC studies show that there is a shift down of 0.5 GeV/c^2 in the extracted mass, and this correction must be applied to the result. Reasonable changes in the cutoff on $P_{\rm bkg}$ do not have significant impact on M_t.

Figure 4 shows the value of $L(M_t)/L_{\rm max}$ as a function of M_t for the 22 events that passed all selection criteria, after correction for the above top mass bias. To obtain $L_{\rm max}$, the likelihood was maximized with respect to the parameters c_i at each mass point. The Gaussian fit in the figure yields $M_t = 180.1$ GeV/c^2 with a statistical uncertainty of $\delta M_t = 3.6$ GeV/c^2.

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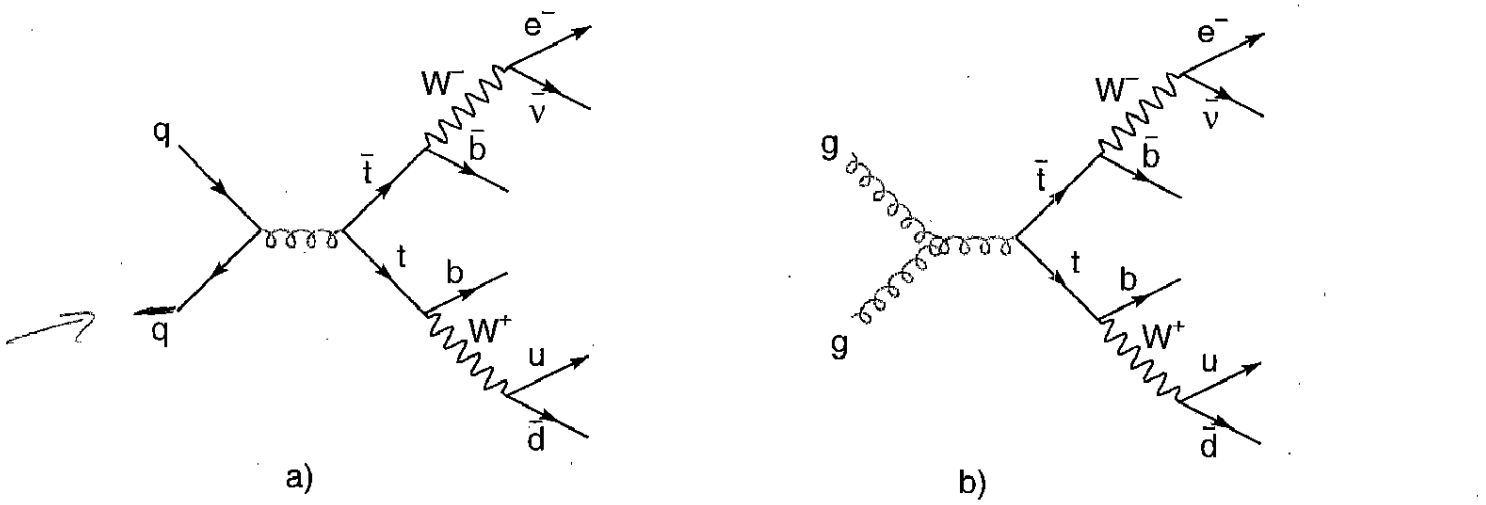

Figure 1: Feynman diagrams for $t\bar{t}$ production in $p\bar{p}$ collisions, with subsequent decays into an electron, neutrino, and quark jets. Diagram (a) (quark-antiquark production) is dominant, but diagram (b) (gluon fusion) contributes an additional 10% to the cross section.

$t\bar{t}$ production at the Tevatron

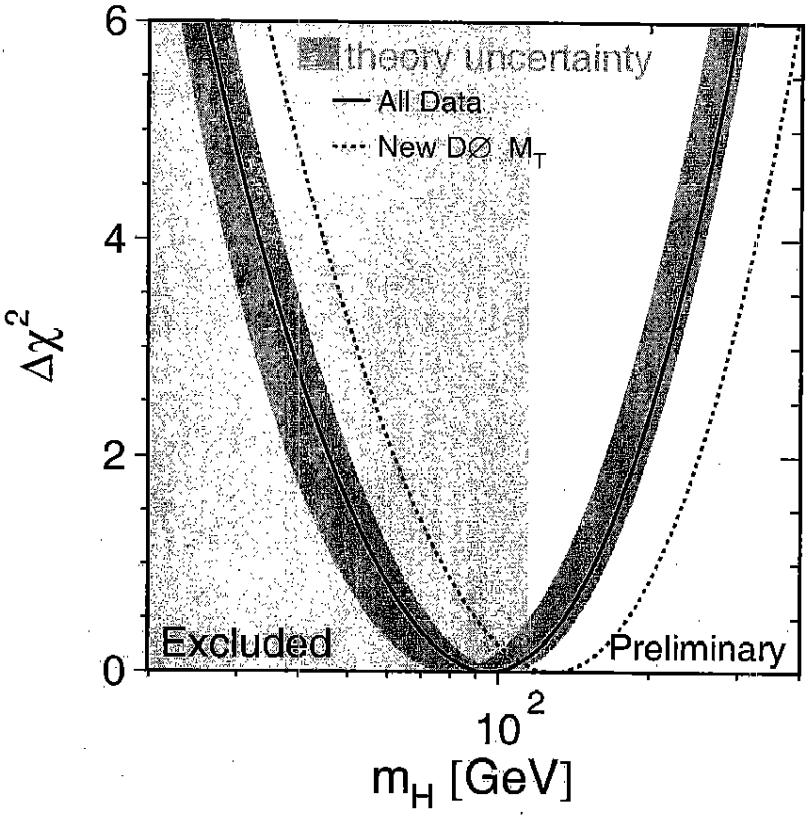

Figure 2: χ^2 for a global fit to all available electroweak data using the procedure of Ref. [2], as a function of the Higgs boson mass. The solid ~~line~~ curve corresponds to the previous world average for ~~the top mass~~ M_t of 174.3 ± 5.1 GeV/c^2, with the blue band indicating the impact of theoretical uncertainty. The dashed ~~line~~ curve corresponds to the new DØ average for ~~the top mass~~ M_t of 179.0 ± 5.2 GeV/c^2. The yellow shaded area on the left indicates the region of masses excluded by experiment. The improved top mass measurement eliminates the previous conflict between the most likely value of the Higgs mass and experimental ly excluded masses.

AWK

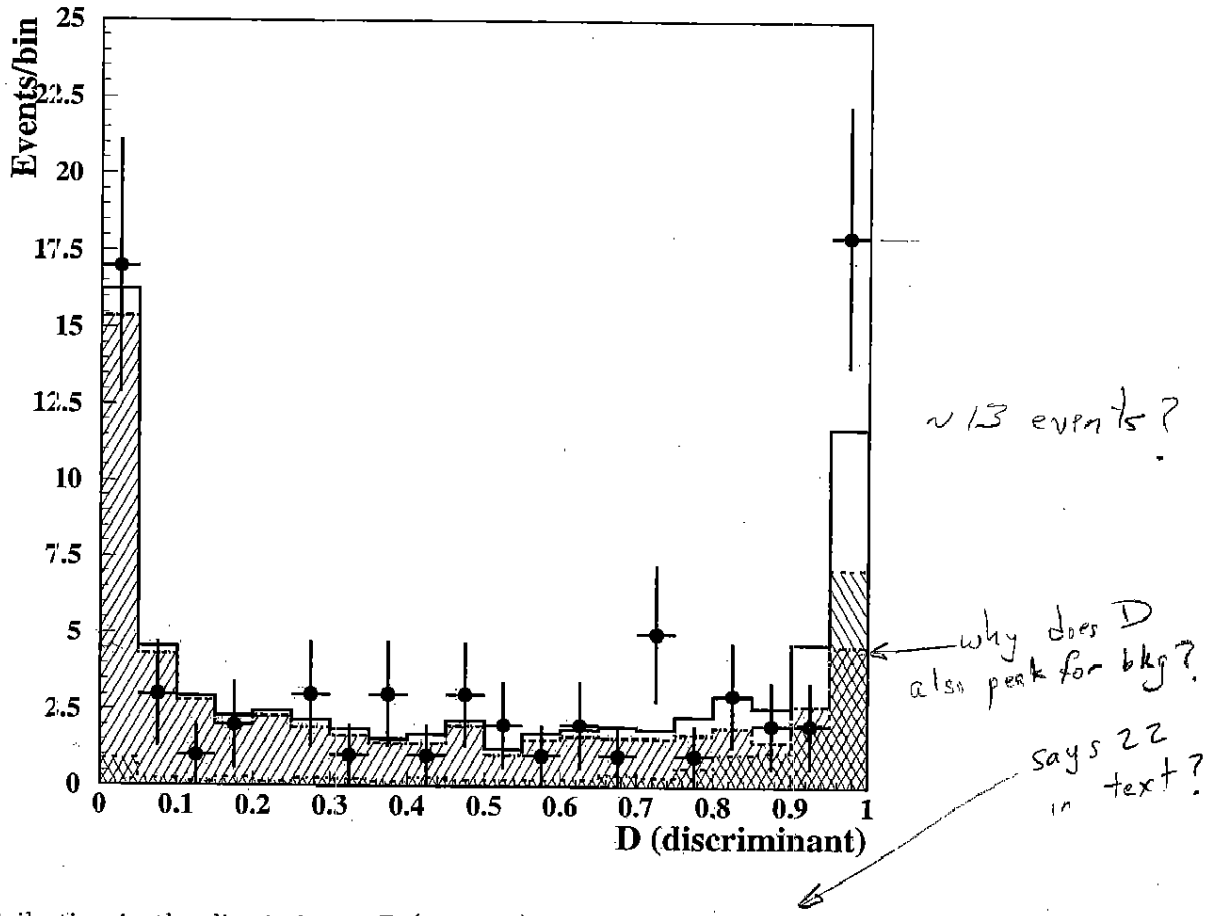

Figure 3: Distribution in the discriminant D (see text) calculated for the 71 $t\bar{t}$ candidates (data points). The data are compared with results expected for the sum (open histogram) of the $t\bar{t}$ signal (red, left-hatched) and W+jets events (blue, right-hatched), simulated with ~~MC~~ Monte Carlo. The data show an excess above W+jets background at large values of the discriminant, characteristic of the $t\bar{t}$ signal.

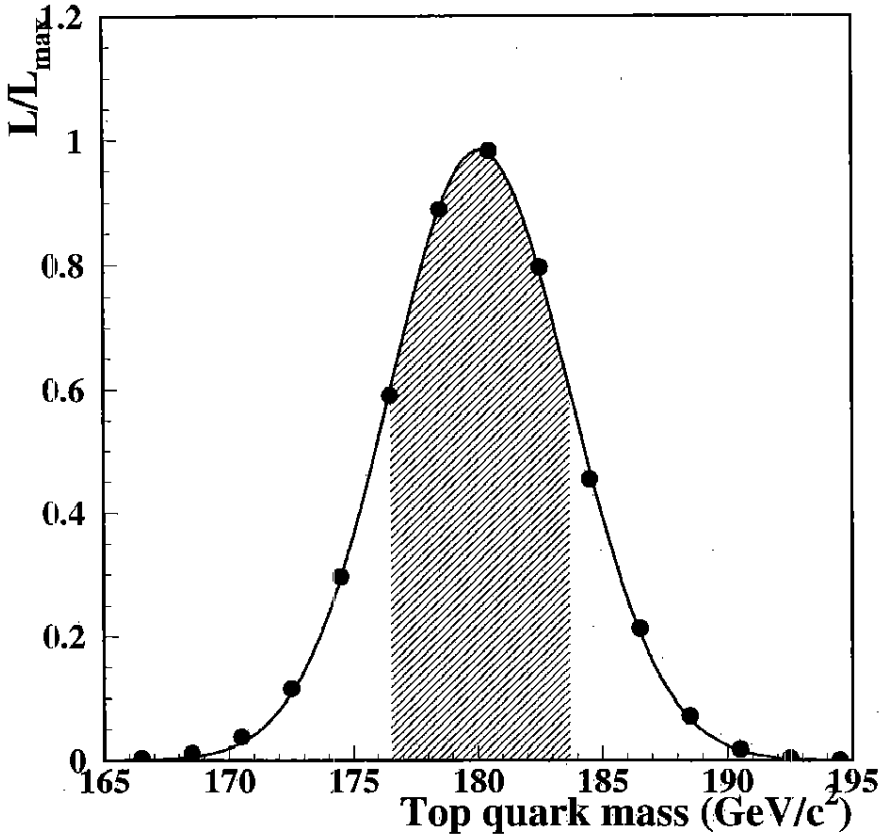

Figure 4: The points represent the likelihood of the fit used to extract the top mass, divided by its maximum value, as a function of the mass of the top quark (after a correction for the -0.5 GeV mass bias, see text). The solid curve shows a Gaussian fit to the likelihood. The maximum likelihood corresponds to the mass of 180.1 GeV/c^2, which is the new measurement of the top mass. The hatched band corresponds to the range of ± 1 standard deviation and indicates the ± 3.6 GeV statistical error of the fit.